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SOME INFORMATION

ON

PORTLAND CEMENT

IMPORTED BY

HOWARD FLEMING,

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PRESS OF WM. C. MARTIN, 111 JOHN ST., N. Y.

PORTLAND CEMENT.

The literature on this subject has been much enlarged of late years, and to describe its manufacture is therefore unnecessary. When properly made it is chemically described as a double silicate of lime and of alumina, and possesses the property of setting and hardening under water.

Chemical Analysis demonstrates whether a cement contains only its due percentage of lime, and also by the percentage remaining of carbonic acid whether this lime has been properly combined, during the process of burning, with the silica and alumina. It has no exact relation to the strength of cement.

This is most important to engineers and contractors, as the true cause of failure in concrete work may, in nearly all cases, be traced either to the use of an *excessive proportion of lime* in the original mixture or to some of the lime being present after burning in the "*free*," *i. e., not chemically combined, state.* This is indicated at once by the percentage of carbonic acid, which should in no case exceed 1.50 per cent.

The composition of a thoroughly sound Portland Cement, such as "Gibbs'," averages as follows:

Lime	59.47
Soluble Silica	23.63
Insoluble "	1.17
Alumina and Ferric Oxide	10.87
Carbonic Anhydride	1.00
Sulphuric "	1.65
Alkalies, Moisture, etc	2.21
	100.00

A separate determination of magnesia showed the highest percentage present to be .79 and the lowest .46, giving a mean of .62.

It is with cement of this quality that the following, of many, important works have been supplied without one single case of failure:

Croton Aqueduct ..... New York.
Buffalo Breakwater..... "
American Docks..... "
East River Sea Walls..... "
Fort Adams..... ..... Newport Harbor.
Concrete Sea Walls.... ..... Charleston, S. C.
" " ..... Long Branch, N. J.
Quebec and Esquimault Docks,
New Haven Harbor, etc., etc.

Weight per bushel is only of much importance when taken in conjunction with fineness of grinding; but to get accurate comparative results, the cement should be fed through a standard hopper into a bushel measure also of standard size, placed eighteen inches below its mouth. Fine grinding, however, makes considerable alteration in the weight test, as the following table will show.

An imperial bushel of best cement, freshly ground, passing through an

		Per Cent.		
80 Mesh Sieve,	and leaving	10	residue, weighs	110 lbs.
"	"	20	"	116 "
"	"	25	"	121 "
"	"	35	"	123 "

When weight per bushel is specified, it can only be ascertained by weighing a whole bushel; to weigh a given part and then multiply will not give a correct result. All cement increases in bulk with age, therefore the weight per bushel becomes proportionately lighter. For this reason there will

often be a discrepancy after a long voyage of several pounds, between the weight per bushel on arrival and that ascertained at the time of shipment.

An imperial bushel of cement, which weighed when

One day old	117 lbs.,	reweighed
One month later	113 "	"
Two months later	108 "	"
Twelve months later	103 "	"

Fineness of Grinding has been proved by Mr. John Grant and other authorities to be a most important factor in the strength of concrete, and should therefore have special attention. The extra cost of production to some extent counteracts the higher quality obtained, but the following degrees of fineness should be at least required:

	Per Cent.	*Mesh Sieve.*
For ordinary purposes to leave under	10 residue on	2,500
For special work " "	10 "	6,500

Messrs. Gibbs & Co. have paid special attention to fine grinding, and their machinery is so arranged that their cement is in accordance with the latest specifications of the London Board of Works, which requires that not more than twenty per cent. of residue should be left on a sieve of 5,766 holes to the square inch.

Water test is one of the safest guards as to the soundness of cement.

Thin cakes or pats should be made up and placed upon pieces of glass or other non-absorbent material, and then, when thoroughly set, one cake should be immersed in water, the other being kept in the air. Care should be taken that the cement is thoroughly set before immersion, and for a slow-setting quality the pats may sometimes require twenty-four hours to become so. If after this the pats show cracks on the outer edge, the cement should not be passed unless it can be proved

that the defect is due only to freshness of grinding, and can therefore be thoroughly remedied by air slacking.

A further useful test is to fill a test tube with gauged cement. Good cement always expands slightly, so that in course of two or three days the tube will crack; if, however, the expansion is so great as to blow the glass to pieces the cement should be regarded with suspicion.

Tensile strength is one of the conditions of a specification most stringently enforced. At the same time it should be remembered that it is a test which depends greatly on the state of the atmosphere, and still more on the skill of the manipulator.

With regard to the latter point, it is by no means an infrequent occurrence to find two men making briquettes from the identical cement, producing results varying from twenty-five per cent. to thirty-three per cent.

COMPARATIVE TESTS OF THE SAME CEMENT.

TENSILE STRENGTH PER SQUARE INCH AT SEVEN DAYS.

A. Southam, Esq.	Hy. Faija, Esq.	Gordon & Co.	Eastwood, 1.	Eastwood, 2.	Gibbs.
lbs. 290	lbs. *389	lbs. 466	lbs. †372	lbs. †510	lbs. 525

* Broken at the rate of 100 lbs. per 15 seconds.
† Made up by the same gauger.

It is very important that tests should be made by skilled labor, and under fixed conditions of temperature, proportion of water, &c., and the writer has added at the end some rules, which if adhered to, will be found to assist in obtaining accurate results.

A comparison of tests of different cements is invidious, and regarded with suspicion unless made by one man at the same time under conditions favorable to each brand, and it is derogatory to the intelligence of an architect, engineer or buyer to

present them. Cement supplied under a contract has been tested by different persons, and the record for tensile strength at seven days age on the square inch was as high as four hundred and eighty-five pounds, and as low as sixty pounds.

The true strength of the cement was the highest record. The low record was due to faults in manipulation through the unskilfulness of the gauger. Unprincipled men would make use of the latter to the possible detriment of a safe and sound cement.

The following extract is from a paper read before the American Society of Civil Engineers, on the improvement of the Harbor of Quebec:

"THE cement used in these works was English Portland, manufactured by **GIBBS & CO., London.** Over 14,000 barrels have "been used, all of which was subjected to a rigid test of its tensile "strain, viz., 750 lbs. to a section of $1\frac{1}{2}$ inches square.

"Many experiments prove that the smallest amount of water that can "be used and yet make a good stiff composition, without sweating or "weeping, gives the best results, as shown by the following table:

No. of Bbl.	Oz. of Neat Cement.	Oz. of Water.	No. of days in Water.	Tensile Strain $1\frac{1}{2}$ in. square.	Temperature.			Remarks.
					Air.	Water.	Cement.	
573	25	$5\frac{1}{2}$	7	840	57	54	58	
573	25	4	7	1060	62	58	60	Minimum of Water.
572	25	$5\frac{1}{2}$	7	770	58	54	58	
572	25	4	7	980	62	61	62	Minimum of Water.

"It will be seen that by the use of the minimum amount of water, a "considerable gain in strength is obtained. For testing tensile strength "a lever-balance machine is used, manufactured by Patrick Adie, "London, England."

CONDENSED TABLE OF CEMENT TESTS.

Date. 1879.	The number of Briquettes from which average is taken.	Tensile strain for 1 sq. inch.		Weight in pounds of Imperial struck Bushel.	Number of ounces of neat cement to each Briquette.	Average Temperature.			Average ounces of Water in each Briquette.
		7 days in Water.	30 days in Water.			Air.	Water.	Cement.	
June.	164	465.6	.....	116½	25	56.7	54.7	56.2	5.33
June.....	76	.....	525.2	"	"	56.7	54.7	56.2	5.33
July...	194	528.04	... .	115½	"	60.8	60.6	60.9	4.69
July	94	.....	608.32	"	"	60.8	60.6	60.9	4.69
August.....	164	573.84	.... ..	"	"	61.0	58.7	62.0	4.84
August.....	82	.....	646.6	"	"	61.0	58.7	62.0	4.84
September..	156	565.2	.....	115½	"	56.2	54.6	56.2	4.70
September ..	31	.....	651.2	"	"	56.2	54.6	56.2	4.70

The raw materials forming Portland Cement—chalk and clay—when burnt to the proper degree form a very hard clinker, which is expensive to grind to the fineness now demanded by engineers, as the machinery requires constant repair. Some manufacturers therefore experimented in methods to cheapen the cost of production which was further induced by keen competition, and this provoked the introduction of other materials, notably slag. These efforts that were not altogether crowned with success were directed towards a saving in fuel (coke), which enters heavily into the cost of cement making. To this clinker iron slag meal is added, and the grinding is easier and softer, but the result is not a true Portland Cement.

Before this process was introduced, Mr. John C. Trantwine cautioned engineers and contractors in the following words: **"Many spurious and inferior articles are sold under the name of Portland Cement."**

The specific gravity of best Portland Cement is never below 3.02, and by this test adulteration can be detected. It is confirmed by the fineness of the cement or the residue left on a sieve having 2,500 meshes to the square inch. Taking Gibbs' Portland as a standard, as they are the only makers that label each barrel as follows:

GIBBS & CO.'S BEST PORTLAND CEMENT.
DIAMOND ◇G◇ BRAND.
Warranted free from Iron, Slag or any Adulteration.

and comparing them with other makes, the following results have been reached:

	Sp. Gr.	Residue on 2,500 Sieve.
1. Gibbs	3.05	9.15 %
2. K. B. S	3.02	12.34
3. G. & Son	2.95	3.90
4. I. C. J	2.90	2.34
5. Slag	2.60	0.39

This list could be prolonged, but it is sufficient for the purpose. Tests of Nos. 3 and 4 show adulteration, whilst No. 5 is Slag Cement sold as Portland.

Slag Cement has been for some time manufactured in Germany, and works have also been started in England for its production. Being a mechanical mixture of iron slag with slacked lime it is very different in its constitution from Portland Cement, which is a true chemical combination. It is distinguished by its light specific gravity and by its color, which is of a mauve tint, in powder, whilst the inside of the water pat when broken is deep indigo. Its presence when mixed with Portland may be detected as follows, viz.: To a gill of water is added about a drachm and a half (eighty drops) of sulphuric acid. Into this twenty-five grains of the cement is dropped and quickly stirred, so as to prevent any setting,

and then immediately and whilst still stirring, Condy's fluid is allowed to fall in drop by drop until the red color remains permanent. Genuine Portland will require only ten to fifteen drops of the fluid, whilst an adulterated cement will take considerably more (thirty to sixty), and a cement made from slag, over two hundred drops.

The result of this test was as follows:

	Grains Cement.	Drops C. Fluid.	Drops C. Fluid. per cent. Grains.
1. Gibbs	25	14	56
2. K. B. S	25	15	60
3. G. & Son	25	35	140
4. I. C. J	25	60	240
5. Slag	25	220	880

Mr. H. B. Yardley, analytical chemist, has also formulated the following as a simple test for the same purpose, viz.: to place upon a clean silver coin a thin layer of cement, dropping thereon a small quantity of dilute sulphuric acid (one acid to seven water), and afterwards rinsing with water. If the cement is genuine Portland the treatment will only slightly affect the color of the silver; but if slag is present in any notable proportion, a dark brown stain will be produced.

The following is the result of this experiment on the cements named:

1. Gibbs.
2. K. B. S. } Light Brown Stain.
3. G. & Son.
4. I. C. J. } Very Dark Brown.
5. Slag. Almost Black.

Cement adulterated with slag and slag cement will be found finer ground and quicker setting than Portland, and it will attain its maximum strength at a shorter date than best Portland, but retrogression then takes place which is most treach-

erous in its nature. The failure of the concrete construction at the Aberdeen Harbor Works is now attributed to the use of cement which was not true Portland, although at first it was considered that the action of the sea water was the cause, but examination of similar constructions built with Gibbs' Portland Cement many years previously proved that when the proper material is employed, and due care exercised in construction, that permanency is assured.

DIRECTIONS FOR TESTING THE TENSILE STRENGTH OF PORTLAND CEMENT.

First. In sampling a quantity, cement from several casks should be shot in a heap and well turned over together, the briquettes being made from this mixture. If samples are only taken from the top of the casks, there is danger of the cement having become dead, and therefore not fairly representing the bulk.

Second. Spread out the sample for a few hours before gauging, so that it may become thoroughly cool and air slacked. **This is especially important in hot weather.**

Third. Always weigh both cement, sand and water before gauging, as a very slight excess of the necessary amount of sand or water will materially affect the result. See Grant on Cement, page 157, where Mr. Parkes says:

"There would sometimes be a difference of 100 per cent., or 150 per cent., without any apparent cause, in the breaking strain of two bricks made from the same sample; consistent results could only be obtained by adopting exact proportions of cement and water. In one experiment, he used four-tenths of a pint of water for each test block, when the breaking weight in four cases was 970 lbs., 980 lbs., 1,000 lbs., and 980 lbs. After that he made up two more samples, mixed with a half-pint of water instead of four-tenths of a pint, and these

broke with 590 lbs., and 370 lbs.; two others made up with nine-twentieths of a pint broke with 750 lbs. and 375 lbs." Unfortunately every sample will require a varying amount according to the nature of its setting (quick or slow), fineness of grinding, and the state of the atmosphere, but as a rule from 18 to 20 per cent. will be sufficient, where 1-inch moulds are used.

Fourth. Carefully clean the moulds with a slightly greasy cloth, and place them on iron plates.

Fifth. Do not attempt to gauge too much cement at a time. If using 1-in. moulds, weigh 6½ oz. cement and 1¼ oz. water to fill one mould, or 20 oz. cement and 4 oz. water enough to fill three moulds; if for 1½ in. mould, weigh 40 oz. cement and 8½ oz. water. Add the water little by little, working with a trowel until the mixture becomes a short harsh paste, discontinue adding water, but continue working with the trowel for a few minutes, when the paste will become fat and smooth. If only the proper quantity of water has been added, the sample will be stiff enough to stand with a straight edge, but if too much it will almost flow. In filling the moulds considerable care is required to get rid of the air in the cement and make the briquette solid. The whole operation of gauging and filling the moulds should not occupy more than 4 to 5 minutes, and the quicker it is done, provided it is done properly, the better will be the result, for it is most important that the cement should be at rest before the setting action commences. The best form of moulds are those which screw together, and when these are used the briquettes should not be taken out until 24 hours after gauging. This "taking out" requires great care to avoid flaws, especially when "press" or spring moulds are used.

Atmospheric influence. Heat and cold have both an important effect on the tensile strength of cement; there-

fore, care should be taken that during summer **the atmosphere of the testing-room is not so dry as to cause undue evaporation** of the proper proportion of the water added in mixing the test bricks, and that in winter the temperature does not fall so low as to cause this proportion of water to freeze before a thorough combination takes place.

Temperature of Water. It is also necessary for obtaining correct results that the temperature of the water used for gauging should be as nearly as possible the same during all seasons of the year, viz.: about 60′ Fahrenheit.

The extensive use of Gibbs' best Portland Cement proves that it is regarded as superior to other makes, and although a little higher priced the difference is not apparent when its reliability and thorough uniformity is considered. It is especially suitable for concrete construction, foundations, etc., etc.

All barrels are lined with waterproof material and securely coopered to ensure delivery of full weight.

Barrels weigh on average.....400 pounds.
" contain about.....3½ bushels.
" measure, loose.....4.25 cubic feet.

CONCRETE MIXING.

Good Concrete can be made from clean gravel and sand, river ballast, stone chippings, burnt clay, shingle, broken bricks, crushed flints, etc., etc.; and the proportion generally adopted by engineers is one of cement to eight of these of similar materials, technically termed the aggregate.

To ensure satisfactory results, the following precautions should be taken :—

1. To use *clean* water only.

2. The cement and aggregate should be raked or turned over together twice dry, and this operation again repeated whilst the water necessary for hydration is being added. This should always be poured through a rose (an ordinary watering-pot is as good a means as any), as throwing on from buckets washes the cement away from the aggregate. Repeat the mixing once more and the concrete is ready, *i. e.*, it has been turned over four times—twice dry, once whilst being watered, and once afterwards.

3. When the aggregate consists of crushed bricks or other porous material, it should be thoroughly wetted, and time allowed for absorption previous to use, otherwise it will take away part of the water necessary to effect the setting of the cement.

4. It is often desirable to add a proportion of sand to the aggregate to assist to fill up the corners. When this is done, care should be taken that the sand is sharp and clean—the coarser the better.

5. Concrete should be used at once after mixing, as to re-mix or disturb when partially set destroys its setting property.

6. When used for plastering over brickwork, this should be first well wetted.

7. Medium slow-setting cement gives, eventually, the strongest concrete.

The proportion of eight and one is named as that usually specified; but with good tested cement a larger proportion of aggregate may be added.

These hints will be found useful in preventing the misuse of cement, but the writer would recommend all who are interested to know what cement can do for engineering works

to read "Grant on the Strength of Cement;" or, for more general purposes, "Portland Cement for Users." H. Faija, C. E., and "Concrete: Its Use in Building," by Thos. Potter.

Attention is requested to the following testimonials:

LYNN, Mass., *Nov.* 20, 1885.

SIR: Having occasion to use a large quantity of Portland Cement in the construction of Section 1 of the Lynn Intercepting Sewer, I found the Gibbs' Cement superior in quality and making from ten to fifteen per cent. more mortar than any of the other brands tried.

CONRAD JUUL, *Contractor.*

The eminent consulting engineer, Mr. C. H. Latrobe, C. E. of Baltimore, reports tests of Gibbs' Portland Cement as follows:

The cement was mixed pure with enough water to ensure its cohesion, and was then well rammed into brass moulds on a slate table at a temperature of between 65° and 70° Fahr. The briquettes were broken on a Riehle machine, and the average tensile strength was as follows:

At	1 day.....	137.5	lbs. per square inch.
"	6 "	374.2	" "
"	10 "	453.6	" "

The range shows great uniformity and proper increase in strength.

Extract from letter dated 5th December, 1887, written by the engineer, Capt. F. A. Mahan, U. S. Engineer Corps, to Mr. Howard Fleming, 23 Liberty Street, New York:

In the construction of the new superstructure of the breakwater at Buffalo Harbor, N. Y., ***Gibbs' Portland Cement*** was used for the outside of the masonry structure, whether that outside was of cut stone masonry or of concrete.

On the morning of October 3d, a very strong gale sprang up. The sea was soon washing over the work. The concrete backing of natural cement, not having had time to harden, was carried away entirely, and *the wall was left standing by itself and unsupported for a space of probably fifteen hours.* The entire duration of the gale was forty-eight

hours. After it was over I made a thorough examination of the wall and found that, notwithstanding its severe buffeting, *there was not a crack or flaw to be found* in the mortar, which had been made of two parts of sand to one of cement.

This is as good a test, to my mind, as the cement could receive.

NEWHAVEN HARBOR COMPANY,
ENGINEER'S OFFICE,
LONDON BRIDGE, S. E., *October 2d*, 1885.

GENTLEMEN: I have great pleasure in stating that the Cement supplied from Gibbs' Works at Grays, to this Company, amounting to about ***50,000 barrels,*** has given entire satisfaction. It has stood well all the tests we have applied, both as to weight and tensile strength, and has made first-rate concrete.

We have used it both in the sea walls and the breakwater at Newhaven, and there has not been the SLIGHTEST FAILURE in any of the work made by your Cement during the five years we have been using it.

I am, gentlemen, yours faithfully,

(Signed) FRED. DALE BANISTER,
Chief Engineer.

NEW TAY VIADUCT,
ENGINEER'S OFFICE,
DUNDEE, *6th September*, 1887.

GENTLEMEN: We have much pleasure in expressing our complete satisfaction as regards the excellent quality of the ***10,000 tons of Portland Cement*** supplied, through you, by ***Messrs. Gibbs & Co., Limited, Grays, Essex,*** to the above works.

In order to obtain the best Portland Cement, our specification required it to be ground so fine that the residue on a sieve having 5,800 meshes per square inch should not exceed 10 per cent. by weight, and that when mixed with three parts of sand it should bear, without breaking, 170 lbs. per square inch twenty-eight days after moulding the briquettes.

We are glad to be able to say that every shipment has not only fully complied with our requirements, but that the average breaking strain with the sand mixture has been 210 lbs. per square inch, and that the briquettes made of neat Cement have averaged 435 lbs. per square inch seven days after date of moulding.

Yours truly,

(Signed) BARLOW & SON.
(Signed) FLETCHER F. S. KELSEY,
Resident Engineer.

Reference is also permitted to

Messrs.	Lesley & Trinkle	Philadelphia, Pa.
"	Magee & Co	Allegheny, Pa.
"	Wood Bros	Cleveland, O.
"	Meacham & Wright	Chicago, Ill.
"	Cutler & Gilbert	Duluth, Minn.
"	Sherman Bros. & Co., Ld	Buffalo, N. Y.

who have supplied large and important contracts with

GIBBS' PORTLAND CEMENT.

HOWARD FLEMING,

23 LIBERTY STREET, NEW YORK,

IMPORTER OF

PORTLAND CEMENT

OF SUPERIOR QUALITY.

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KEENE'S CEMENTS.

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MORTAR COLORS,

RED – BROWN – BUFF – BLACK.

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